Lokomat® Clinical Report

Where leaders in rehabilitation of neurological disease & trauma tell how they enhance care with the Hocoma Lokomat System

Spaulding Rehab's spinal cord injury program helps patients walk with Lokomat System

"Our spinal cord program averages about 200 admissions a year. They range from workman's comp injuries – we recently admitted a patient who had some siding fall on this head – gunshot wounds, and survivors of car accidents."

Spaulding Rehabilitation Hospital is one of the nation's premier rehabilitation hospitals, serving patients who've suffered stroke, spinal cord injury, orthopedic, cardiovascular and neurological injuries, disorders and diseases. Its gait research activities are headed by Paolo Bonato, PhD. Dr. Bonato's R&D team is currently evaluating the use of Hocoma's new pediatric Lokomat in the rehabilitation of children with cerebral palsy.

Kevin Alvares, PhD and Amy Murgatroyd, MSPT are Advanced Clinicians at Boston's Spaulding Rehabilitation Hospital spinal cord unit. Murgatroyd has 8 years of clinical experience in SCI treatment and came to Spaulding last year. Alvares joined Spaulding five years ago after graduating from Massachusetts General Hospital Institute of Health Professions.

Kevin Alvares, PhD
Advanced Clinician
Spinal Cord Injury Program

Amy Murgatroyd, MSPT
Advanced Clinician
Spinal Cord Injury Program

How does gait therapy for spinal cord injured patients begin here at Spaulding?

Kevin Alvares: The therapy begins very early, as soon as patients are stable enough to leave the acute care setting and move on to rehabilitation.

The focus is on their full rehabilitation, encompassing physical therapy, occupational therapy, speech therapy, and therapeutic recreation. We go through a full assessment on each patient, and we begin to mobilize them from day one of the assessment. We then establish a treatment program. In addition to individual therapy, they participate in group therapy, an education series, and modalities like the Lokomat if it's appropriate.

Early goal: Enhance response to verticalization

How do you verticalize a patient prior to initiation of therapy?

Amy Murgatroyd: One of our early goals for a patient is to improve their hemodynamic response to being upright. Upon admission we're working to improve their sitting tolerance and response to changes in position. An early treatment is the tilt table, on which a patient is progressively brought from full supine to vertical, while we monitor their vitals and response.

Initially they may require compression garments to tolerate a vertical position. Over time we progress to a standing frame then

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In addition to its clinical services, Spaulding is one of the nation's leading rehab research centers. It is the first site for Hocoma's new pediatric "legs" that can be attached to any Lokomat. Spaulding's Paolo Bonato, PhD, is studying the use of this new system in the treatment of cerebral palsy.

once they are hemodynamically stable, into the Lokomat.

Once a patient can tolerate being verticalized, what's the next step? How do you determine whether a spinal cord injured patient is ready to begin more active therapy? What are some of the indications you might look for?

Murgatroyd: At this facility, in terms of Lokomat training, we are prioritizing ASIA C and D patients that have had some motor return in their lower extremities. Once we're seeing even a small amount of active movement and the patient can tolerate being vertical, then we're ready to proceed with Lokomat training. ASIA B patients who have a good prognosis for return to ambulation are also appropriate candidates.

What kind of therapy can you offer ASIA A patients at Spaulding?

Murgatroyd: There are certainly some benefits of the Lokomat for ASIA A patients such as range of motion, tone management, lower extremity circulation, and then all the benefits of weightbearing, which include bone density. It's the desired outcome of Lokomat training we have to carefully consider. If the patient's prognosis is poor for returning to ambulation, there are more appropriate means of achieving the same benefits.

Spaulding Hospital Spinal Cord Injury Program

Christopher Diehl PT, MHP

Director of Physical Therapy
Spinal Cord Injury Program Director
Musculoskeletal Program Director
Spaulding Rehabilitation Hospital

Christopher Diehl: Our spinal cord program averages about 175 admissions a year. They range from workman's comp injuries to gunshot wounds, and survivors of car accidents and falls. We've seen patients ranging from 16 to 80. We see complete and incomplete spinal cord injuries, and a few central cord injuries, where the patient's legs aren't as impacted as their upper extremities. We have the capacity to take 10 ventilated patients into our rehab program.

Under our Medical Director Dr. Kevin O'Connor, our unit typically employs both functional-based rehabilitation as well as neurological recovery. Our objective is not only to help our patients to become functional in the community, but also to help there generalized neurological recovery.

What percentage of the patients who receive Lokomat System therapy at Spaulding are inpatients versus ambulatory outpatients?

Diehl: Roughly 80% are inpatients. In addition to spinal cord injured patients, we provide Lokomat therapy for patients with traumatic brain injuries and stroke. We also are running a study with our new pediatric Lokomat legs on children with cerebral palsy. Our outpatients are a mix of former inpatients and those who've received their acute care elsewhere. However, the majority of the patients who receive Lokomat therapy at Spaulding are spinal cord patients.

How does Spaulding treatment of spinal cord injuries differ from that at other institutions?

Diehl: I think Spaulding differs from most other rehab centers in the emphasis we place on helping spinal cord patients reenter the community after formal rehab within our facilities.

Spaulding is an active participant in the peer-to-peer program of the Boston chapter of the National Spinal Cord Association. Even while our spinal cord injury patients are in the acute setting, they're visited by people who've suffered similar injuries, and can talk first-hand about what life is like for them

As early in their recovery and rehab as practical, we take them to the Cambridge Galleria mall or to Causeway Street, and have them practice entering stores, restaurants and sporting events, so we can identify what maneuvers in community living most challenge them.

While they're still inpatients, our spinal cord patients are prescribed/fitted to the wheelchairs that they'll will receive when the patients are discharged. We also pressure map our patient so they have proper pressure relief and adequate cushioning.

How is the Lokomat system used in the rehabilitation of your spinal cord injury patients?

Diehl: Our team sits once a week to review all our patients, where we discuss treatment options for each. One of our main focus is neurological recovery. To that end, we use the Lokomat in conjunction with the FES bike as well to help promote that neurological recovery. In using the FES, we attach electrodes to the thigh, quads, and gluteal muscles, and via stimulation, we can deliver therapy that helps with spasticity, hypertrophy of the muscles, and it also helps with cardiovascular training.

Do you do use conventional treadmill-type manual locomotor therapy with body weight support?

Diehl: Yes, we suspend them over the treadmill and have body weight supported locomotor training, but obviously having the Lokomat, we use the Lokomat as our primary mode for locomotor therapy. For some programs throughout the country, manual locomotor therapy is a staple of their program, but as a routine treatment protocol, we usually use the Lokomat.

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"...we use the Lokomat's biofeedback to see if they are actively contributing to what the machine is doing for them."

Alvares: With an ASIA A complete injury, it is difficult to justify a neuromuscular training program. At that stage, there's nothing to respond, although we do try therapies like the motorized FES functional electrical stimulation bicycle. And I think patients are really happy to be doing things where they see movement, even if it's coming from an external source, such as electrical stim or motor-assisted bicycle.

From an overall perspective, their treatment is not very different from those of ASIA C and D patients. They still are getting access to the educational groups, and receive mobility training and community re-entry training, but they may not be appropriate at that stage for some of the neuromuscular training like that provided by the Lokomat.

How, if at all, is your approach to therapy for your ASIA B patients different than ASIA A?

Alvares: If they're a straight ASIA B – no movement and just sensation below their injury – the potential for recovery is wide open.

We look for some sign of neurological recovery, and we do interventions to try to promote that – for example the FES bike. We use weightbearing in the parallel bars, standing frame, the passive range of motion bicycle – anything that may help to stimulate any type of connection between the brain and muscles.

Murgatroyd: And we're reassessing their strength weekly.

Is it too optimistic to hope that some of these ASIA B patients will convert from Bs to Cs?

Murgatroyd: Not at all. One of the best prognostic indicators is bowel and bladder function; if that's maintained or regained, that can indicate a good chance of seeing lower extremity return.

Initiating Lokomat System therapy for ASIA C and D patients

When you initiate Lokomat therapy with ASIA C and D patients, what do you look for? Are you using any of the diagnostics that are built into the Lokomat to do any of the assessment or do you have your own independent assessments?

Alvares: Early on, we're simply determining if they're appropriate for Lokomat therapy. They need to be able to tolerate upright for 15 to 20 minutes, because the first-session setup can take so long that we're happy to get 10 or 15 minutes in on the first session. On subsequent sessions, we're trying to determine their activity tolerance. Once they get into a good training program, we like to have them on for 30 to 45 minutes. It is not uncommon to get over a kilometer of distance in that time frame. Lokomat training has been found to be most effective if you can increase the amount of steps people take compared to overground training, where they might cover just 150 feet in a 45-minute session.

At the beginning, we are looking for a nice kinematically correct gait pattern repeated for

hundreds, if not thousands, of steps. There are starting parameters that we look at in terms of speed of leg movement and how much weight they can bear through their legs while maintaining extension and getting through the mechanics of the extension.

From the beginning, we're looking at their mechanics and making sure they are moving kinematically through a normal-looking gait cycle. We make adjustments as needed, but we try to follow the speed parameters that Hocoma has established for initiation of therapy. And, of course, we use the Lokomat's biofeedback to see if they are actively contributing to what the machine is doing for them. Early on, that biofeedback assessment is especially valuable in determining what they're able to do, especially if they're ASIA B with just a little bit of movement.

What modifications, if any, do you have to make to accommodate very spastic patients?

Murgatroyd: I haven't had an instance where a patient's spasticity overpowered the Lokomat motor, causing the system to stop.

If I have a patient that has high tone, I begin by doing passive ranging and stretching prior to the session, and that's proven pretty effective. For those cases where a patient's tone is so great that it is tripping off the Lokomat, we need to step back and consider how that tone can be managed with meds and various modalities before proceeding with the Lokomat. It can be very difficult for a patient to recruit muscle groups on the Lokomat if they're fighting tone and that's going to decrease the effectiveness of the session.

When you're initiating Lokomat therapy for an ASIA C or D patient, what are reasonable expectations for the first couple of sessions? It must be physically exhausting for most of them.

Murgatroyd: Yes, it really can be so we take it one session at a time. As the setup becomes faster, we'll increase walking time to their tolerance. Other parameters we're affecting, which can contribute to fatigue, are the amount of body weight support and the degree of guidance provided by the motorized legs.

Often, we're doing Lokomat training in parallel with initial overground gait training, then we can progress a patient out of the Lokomat entirely when their overground ambulation has improved to a point that we're comfortable making that the predominant form of training. Body weight support and distance ambulating are good indicators.

When a patient is requiring less than 20% of body weight support from the Lokomat and/or is ambulating overground up to 150 feet, it may be time to discontinue the Lokomat. Overground ambulation enables full patient-mediated gait and allows for normal rotation of the trunk and pelvis which is otherwise blocked in the Lokomat.

A personal preference in treating on the Lokomat is to alternate increased speeds where we're addressing the central pattern generator, with decreased speeds

"We love the Lokomat because it's less labor intensive for us. We can achieve greater treatment duration for the patient and we appreciate the kinematic sequence of it..."

Spaulding therapists Kevin Alvares and Kathelee Banister show how quickly clinics can set up established Lokomat patients like Tim Buttersworth. First, setup of the harness, then hoisting the patient on the Lokomat unweighing system. After attaching the Lokomat "legs to Tim's hips, they attach the leg straps and passive toe-lifters according to patient-specific settings stored on the Lokomat computer hard drive. Typically, setup takes less than 15 minutes, even when done by techs or volunteers, allowing as much as 45 solid minutes of Lokomat therapy per session.

where I'm using the biofeedback and encouraging recruitment of specific muscle groups.

We therapists love the Lokomat because it's less labor intensive for us. We can achieve greater treatment duration for the patient and we appreciate the kinematic sequence of it, but ultimately that patient needs to have a goal of progressing to ambulating in their environment overground.

What are some of the other non-gait-related benefits that you see coming out of Lokomat therapy?

Alvares: Activity tolerance and hemodynamics. I think it's a great way of getting the body accustomed to being upright in more of a dynamic fashion rather than just a standing frame. Psychologically, it has a huge impact and patients really feel good about simulating walking – and psychology is a big factor in patient recovery. I think the repetitive motion of gait training on Lokomat or body weight supported treadmill training can help with tone management and reduction of spasticity.

When patients start ambulating overground, are there any specific machines that are used or is it just simply a harness over a treadmill?

Alvares: As they're coming out of the Lokomat, we may be doing body weight support treadmill training, or overground training with the harness, or at least the harness for starting the session. And they'll often need assist devices such as a platform walker, rolling walker, and bracing in addition to the support that they're getting from the therapist, both physically and cuing them.

One thing that we have to look for: Patients transitioning from the Lokomat are accustomed to a lot of pelvic and trunk support from the harness. When they move to overground training with an assisted device, bracing, and a therapist, their mechanics are usually very different.

That's why we believe they can still benefit from some Lokomat training to keep developing their mechanics. The Lokomat enables us to isolate the couple different muscle groups necessary for gait. But when you have someone with a tetraplegic injury and put them on a walker or platform walker, then we have to take into account what their shoulders and upper limbs are doing for them, how their posture looks. And when they're trying to concentrate on all of those things, you know, they can "lose" what their legs are doing.

"As spinal cord injured patients demonstrate leg strength recovery, we've found the Lokomat valuable in initiating gait training very early."

Murgatroyd: As spinal cord injured patients demonstrate leg strength recovery, we've found the Lokomat valuable in initiating gait training very early. The Lokomat is a great improvement over our previous practice, when we would start with bodyweight support over a treadmill, which had big drawbacks.

What specifically were those limitations?

Alvares: Usually, we would need two to three caregivers or therapists involved, and the biggest limitation was the fatigue factor of the therapists. In my experience, we would get anywhere from seven to twelve minutes of training in before the therapist needed to take a break. Even during those brief training periods, we could reach only limited treadmill speeds. We would do our best, but we just could not simulate heel strike, hip extension and knee extension as efficiently as the Lokomat does.

Spaulding Lokomat case history: Teenage athlete Tim Buttersworth

Let's discuss a few patients you've treated that show how Spaulding is using the Lokomat to rehabilitate spinal cord patients.

Alvares: An excellent example might be Tim, an 18 year old young man injured in a diving accident in July of 2007. When Tim was admitted to Spaulding two weeks after injury, his neurological classification was a C6 ASIA B incomplete tetraplegic injury. He didn't really have any significant movement in his legs. Upper extremity signs were characteristic of a C6 injury. He displayed only trace triceps, slight wrist extension, but no finger flexion – all very typical for what we'd expect to see with a C6 tetraplegic injury. Over the next week and a half, he did tolerate getting into an upright position, so we could start Lokomat training very early in his acute phase – about three to three and a half weeks of the date of his injury –

Over the next two months, we saw steady neurological progress in terms of his manual muscle test scores in his legs, particularly his left leg, which has been evident both with training in the gym and what we see on the Lokomat biofeedback. We were able to get his guidant force down to 10 – between 10% and 20% guidance force from his left leg.

His right leg is weaker, and so during the same period, he's down to 40% guidance force, but he only has a little bit of hip adduction and just trace hip extension. His muscle scores are changing over time and that probably has a lot to do with his

Spaulding patient Tim Buttersworth sets a "personal best" on the Lokomat as therapists Kevin Alvares and Kathelee Banister monitor his efforts.

Lokomat training in addition to the training that he's getting with the FES bike and paddle board. In muscle groups on the right, he has a one for hip extension, so hip extension is one muscle group that we can train on paddle board, and a two minus hip adduction, so that's another muscle group that we train. But I continually check all of his muscles because I do expect that those zeros will turn into numbers as they did in his left leg.

Notable patients: A T10 paraplegic now jogging, a TBI patient learning to walk

Who are some other notable patients you've rehabilitated with the Lokomat at Spaulding?

Murgatroyd: I had a 19-year-old patient who came to us only one week post-injury. He was working under a large truck when the hydraulic lift gave out and it came down upon his back. When he came to us, he had a neurological diagnosis of T10 ASIA B paraplegia. He did have emerging sensation and intact bowel and bladder function. With those indicators, we knew he had a good chance for returning to ambulation – we didn't know with what assist, bracing or device. I was lucky enough to work with him over an extended period – two and a half months.

Upon admission, he had completely flaccid lower extremities but within the first week, he was demonstrating two minus hip flexion on one side. We continued to do a lot of strengthening in parallel with his hemodynamic training on the tilt table and standing frame. At about two weeks after his admission, we began Lokomat training. We continued that for the next month, on average two to three times a week. After set-up, our sessions were between 30 and 40 minutes.

This patient did quite well. He got nice neurological return over the course of treatment. He was able to discharge here ambulating up to 400 feet using bilateral Lofstrand crutches wearing just a right AFO. Today he's a community ambulator. He donated his wheelchair to Spaulding, as well as his crutches, and has progressed to ambulating with no bracing. He recently began jogging again and tells me he has even ran on the beach. We wish all our patients had that level of success.

Everyone likes talking about great successes like that patient. But sometimes, small improvements following Lokomat therapy make the effort worthwhile. Can you think of any Spaulding examples?

Murgatroyd: I collaborated on the treatment of a brain injured patient from our eighth floor head

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About Spaulding Rehabilitation Hospital Network

A member of Partners HealthCare, The Spaulding Network includes its main campus, a 196-bed facility, located in Boston, MA, and eight outpatient sites throughout the Greater Boston area. Spaulding is a teaching hospital of Harvard Medical School as well as the official rehabilitation hospital of the New England Patriots. Spaulding is the only rehabilitation hospital in New England continually ranked since 1995 by U.S. News and World Report in its Best Hospitals survey. For more information, please visit www.spauldingrehab.org

"She tolerated Lokomat training quite nicely. We were able to progress the amount of weightbearing as she did gain some quad control and increase her speed as well."

trauma unit. The primary therapist on that floor was not trained on the Lokomat and so I had the privilege of working with the two of them over the course of two months.

Her therapist decided to attempt gait training when they saw that when they brought her to standing, she was capable of taking some weight to her legs. Being brain injured, she was also quite cognitively impaired.

When I met this patient, she had progressed to walking short distances with a therapist on each side of her, giving max cues – both verbal and physical - for each step. Our goal in training her on the Lokomat was to progress her to the point where the gait sequence might become more automatic and allow for an improved step length on the right.

Because she was cognitively impaired, we couldn't use the Lokomat's biofeedback but our goal was just to work on advancing the right leg, seeing if we could elicit more hip flexion and perhaps draw out of her a more rhythmic stepping pattern. We had to be very sensitive to her responses. During each session, we used signals like thumb up if she was okay, thumb down if she had pain either from the harness, the Velcro cuffs, or the stretch that the Lokomat was giving her.

She tolerated Lokomat training quite nicely. We were able to progress the amount of weightbearing as she did gain some quad control and increase her speed as well. Eventually she advanced to the point of being able to independently advance her right leg and improve her cadence and timing with overground walking. She still needed considerable assist from her therapists due to poor balance reactions but we made these small gains. Today, she continues training in the Lokomat as an outpatient.

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